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MONTHLY REPORT TO THE NUCLEAR INDUSTRY

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TRANSMITTAL

It was a great pleasure to see so many Subscribers and other friends in San Francisco at the AIF Annual meeting. The Nuexco breakfast was attended by more than 160 people and was highlighted by the presence of a special guest—Charlie Steen, discoverer of the first primary uranium ore deposit in the US. His discovery, made in 1952 in the Northern Colorado Plateau district, marked the real beginning of the development of the US uranium industry. The discovery refuted the prevailing belief that only small, low-grade orebodies of secondary mineralization would be found in the US. Mr. Steen's discovery, later known as the Mi Vida mine, set off a surge of prospecting by amateurs and professionals alike. Additional primary orebodies have since been discovered in different geologic environments throughout the western US, but the Steen discovery was the cornerstone of the largest and most successful uranium industry in the world—a tribute to tenacious individualism.

It is also with pleasure that we announce the election of Jerry Reaves as a Vice President of the Corporation. Jerry has been with Nuexco since 1976, and most recently held the position of Manager of Business Development.

We would also like to announce the addition of a new Associate to our Menlo Park staff. W. Scott Hickman has worked part-time for Nuexco since June 1978, and will join us full time in December upon receiving his B.S. in industrial engineering from Stanford University. Scott will assist the senior staff on market studies, consulting reports, uranium transactions and the Monthly Report.

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URANIUM MARKET

GENERAL

US Supply and Demand

In last month's Report, No. 135, an analysis of world supply and demand was published which showed that Apparent Future Consumption as defined by Nuexco could be satisfied, on a world-wide basis, through 1990 with uranium production centers currently in operation or under construction. Moreover, a world-wide inventory ratio of about two years' forward consumption could be continued through 1990 with only those production centers in operation or under construction. Since a two-year forward inventory is an oft-quoted level of comfort, it might be concluded that new production centers would be developed only for political or policy reasons, to accommodate reactors not yet committed to be built, or to replace existing production centers that might, for some reason, close down prematurely.

The same methodology used last month on the world-wide market has now been applied to the US market only, with the results summarized below. In treating the US alone, the potential market can be identified not only for imports, but also for potential US production centers not yet under construction.

In Table 1, Nuexco's estimates of uranium output from operating US centers plus facilities under construction are tabulated through 1990, and are designated "firm production." Also tabulated is Nuexco's annual estimate of Apparent Future Consumption for the US. After adjusting for existing export-import commitments, an annual supply surplus or deficit is determined. If the annual result is a supply surplus, it is assumed to have been added to buyer inventories. If the annual result is a supply deficit, it is assumed to have been removed from buyer inventories. The resulting beginning and ending inventory levels are also tabulated in Table 1 for each year, along with the relative inventory level for that year, in years of forward consumption.

Under the assumptions of Table 1, buyer inventories will continue to grow through the end of 1982, and will fall off thereafter. The relative inventory

Table 1
NATURAL URANIUM SUPPLY-DEMAND BALANCE: US
(x 1,000,000 lb U_3O_8 equivalent)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
PRODUCTION[a]												
Operating Production Centers	38.0	41.6	40.7	38.9	36.9	35.8	35.1	34.0	33.1	32.2	31.3	30.5
plus												
Facilities Under Construction	-0-	1.4	2.6	3.5	5.6	7.0	7.0	7.0	6.9	6.8	6.7	6.6
equals												
Firm Production	38.0	43.0	43.3	42.4	42.5	42.8	42.1	41.0	40.0	39.0	38.0	37.1
less												
APPARENT FUTURE CONSUMPTION[b]	28.6	31.6	38.6	40.0	50.5	46.0	52.6	55.3	54.4	56.3	58.6	55.2
plus												
IMPORT-EXPORT COMMITMENTS (Annual Net)[c]	–1.0	–0.7	3.0	4.3	2.3	2.0	–0.1	1.6	3.0	3.0	3.4	3.5
equals												
SUPPLY SURPLUS/(DEFICIT)	8.4	10.7	7.7	6.7	(5.7)	(1.2)	(10.6)	(12.7)	(11.4)	(14.3)	(17.2)	(14.6)
INVENTORY												
plus												
Beginning Inventory	66.4[d]	74.8	85.5	93.2	99.9	94.2	93.0	82.4	69.7	58.3	44.0	26.8
equals												
Ending Inventory	74.8	85.5	93.2	99.9	94.2	93.0	82.4	69.7	58.3	44.0	26.8	12.2
Beginning Inventory ÷ Apparent Future Consumption = Relative Inventory Level (yrs.)	2.3	2.4	2.2	2.3	2.0	2.0	1.8	1.5	1.3	1.0	0.8	0.5

a. Ref. Nuexco Report No. 134
b. Ref. Nuexco Report No. 132
c. Ref. Nuexco Report No. 135
d. George F. Combs, Jr.: "The U.S. Uranium Market – 1978-1979" USDOE; Grand Junction, Colorado; October, 1979.

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URANIUM MARKET

level will remain at two years or above through 1984, and will consistently drop thereafter. This is an indication of the market available for imports and for new US production. Table 2 has been included as an aid to quantifying this potential market for imports and new production. In Table 2, it is assumed that US buyers will, as a whole, wish to maintain two years' forward inventory. That is, it is assumed that each year's beginning inventory will be at least equal to twice that year's consumption. To accomplish this, an "unfilled demand" would need to be filled as follows (millions of pounds U_3O_8):

	1983	1984	1985	1986	1987	1988	1989	1990
Annual	6.8	0	16.0	18.1	9.6	18.1	21.8	7.8
Cumulative	6.8	6.8	22.8	40.9	50.5	68.6	90.4	98.2

Thus, a continuation of current US buyer inventory policies could lead to a cumulative market for additional imports and new US production of about 100 million pounds U_3O_8 through 1990. However, if buyers decide to reduce general inventory levels, this market could be substantially reduced. For example, if buyers were satisfied with a minimum of an 18-month forward inventory, the cumulative market for additional imports and new US production would be reduced to about 70 million pounds (see Table 3). Indeed, if buyers were to elect to liquidate inventories completely, Table 1 indicates there would be no market for additional imports and new US production through 1990. However, experience has shown that such a policy shift is extremely unlikely.

The following circumstances will tend to increase the market for additional imports and new US production above the levels determined in the foremention examples:

1. More export commitments will be made. This is not expected to be a major influence, but any new commitments to export uranium will increase the "unfilled demand" estimated above.

2. Shifting economics may result in the premature closing of some US production listed above as "firm production." Although this analysis has accounted for estimated depletion of reserves (cf. first line of Table 1, output from operating US production centers decreases from 41.6 million pounds in 1980 to 30.5 million pounds in 1990), it is possible, perhaps even likely, that some operating production centers in the US will shut down prematurely due to unfavorable economics. The real price of uranium has been decreasing for about two years, and some US producers are expecting a cost squeeze which may make cutbacks necessary in economically marginal facilities. Since US production costs are generally higher than those of other uranium-producing

Table 2
NATURAL URANIUM SUPPLY-DEMAND BALANCE: US
(Assumes US Buyers Maintain At Least 2 Years' Requirements in Inventory)
(x 1,000,000 lb U_3O_8 equivalent)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
APPARENT FUTURE CONSUMPTION x 2[a]	57.2	63.2	77.2	80.0	101.0	92.0	105.2	110.6	108.8	112.6	117.2	110.4
less												
BEGINNING INVENTORY	66.4[b]	74.8	85.5	93.2	99.9	101.0	99.8	105.2	110.6	108.8	112.6	117.2
– Annual Supply Surplus/	8.4	10.7	7.7	6.7								
+ Annual Supply Deficit[c]	—	—	—	—	5.7	1.2	10.6	12.7	11.4	14.3	17.2	14.6
equals												
UNFILLED DEMAND[d]	-0-	-0-	-0-	-0-	6.8	-0-	16.0	18.1	9.6	18.1	21.8	7.8
ENDING INVENTORY[e]	74.8	85.5	93.2	99.9	101.0	99.8	105.2	110.6	108.8	112.6	117.2	110.4
Beginning Inventory ÷ Apparent Future Consumption[a] = Relative Inventory Level (yrs.)	2.3	2.4	2.2	2.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

a. Ref. Nuexco Report No. 132.
b. George F. Combs, Jr.: "The U.S. Uranium Market – 1978-1979" USDOE; Grand Junction, Colorado; October, 1979.
c. Ref. Table 1.
d. Unfilled Demand is defined as that additional amount of uranium, if any, which US buyers would have to purchase over and above US firm production in order to maintain a certain minimum Relative Inventory Level (Two years in Table 2, Eighteen months in Table 3).
e. Under the assumptions of Table 2, Ending Inventory is derived as the greater of Beginning Inventory +/– Annual Supply Excess/Deficit and Apparent Future Consumption (Annual) x 2.

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Table 3
NATURAL URANIUM SUPPLY-DEMAND BALANCE: US
(Assumes US Buyers Maintain At Least 18 Months' Requirements in Inventory)
(x 1,000,000 lb U_3O_8 equivalent)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
APPARENT FUTURE CONSUMPTION x 1.5[a]	42.9	47.4	57.9	60.0	75.8	69.0	78.9	83.0	81.6	84.5	87.9	82.8
less												
BEGINNING INVENTORY	66.4[b]	74.8	85.5	93.2	99.9	94.2	93.0	82.4	83.0	81.6	84.5	87.9
– Annual Supply Surplus/	8.4	10.7	7.7	6.7								
+ Annual Supply Deficit[c]	—	—	—	—	5.7	1.2	10.6	12.7	11.4	14.3	17.2	14.6
equals												
UNFILLED DEMAND[d]	-0-	-0-	-0-	-0-	-0-	-0-	-0-	13.3	10.0	17.2	20.6	9.5
ENDING INVENTORY[e]	74.8	85.5	93.2	99.9	94.2	93.0	82.4	83.0	81.6	84.5	87.9	82.8
Beginning Inventory ÷ Apparent Future Consumption[a] = Relative Inventory Level (yrs.)	2.3	2.4	2.2	2.3	2.0	2.0	1.8	1.5	1.5	1.5	1.5	1.5

a. Ref. Nuexco Report No. 132.
b. George F. Combs, Jr.: "The U.S. Uranium Market – 1978-1979" USDOE; Grand Junction, Colorado; October, 1979.
c. Ref. Table 1.
d. Unfilled Demand is defined as that additional amount of uranium, if any, which US buyers would have to purchase over and above US firm production in order to maintain a certain minimum Relative Inventory Level (Two years in Table 2, Eighteen months in Table 3).
e. Under the assumptions of Table 3, Ending Inventory is derived as the greater of Beginning Inventory +/– Annual Supply Surplus/Deficit and Apparent Future Consumption (Annual) x 1.5.

nations, a prolonged buyers' market may tend to shift production out of the US.

3. New reactors may be ordered. However, due to long construction lead times in the US, new reactors are not expected to add significantly to demand until beyond 1990.

The remainder of this section is a detailed description of the methodology and assumptions used to produce the data in Tables 1, 2 and 3.

1. A critical assumption is that uranium production centers in operation or under construction as of this writing will be able to sell their projected U_3O_8 output. Much of the material defined as "firm production" is already committed by contract for future deliveries. In some cases, the production facility's future output is committed to a single buyer, through direct utility participation in uranium supply, or otherwise. It is assumed that the remainder of total projected output can be sold, even if only for inventory accumulation in a time of apparent excess supply.

2. Table 2 assumes that buyers will seek to maintain a collective inventory level equivalent to **at least two years'** requirements. This assumption has two critical implications:

a. When, after taking into account exports, imports and annual consumption, annual US production is enough, or more than enough, to maintain inventory equivalent to two years' requirements, any excess production will be added to buyers' inventories.

b. When, after taking into account exports, imports and annual consumption, annual US production is insufficient to maintain inventory equivalent to two years' requirements, US buyers will acquire the additional uranium through some combination of increased imports and purchases of new US production not yet under construction.

3. Table 3 assumes that US buyers will seek to maintain a collective inventory level equivalent to **at least 18 months'** requirements. Its implications correspond to those of the two-year assumption for Table 2.

4. Planned production centers—those with production plans and identified ore reserves, but which have not yet begun construction—are not included in this analysis. Only production estimates for production centers operating or under construction were included in the "firm production" component. The methodology for Nuexco estimates of U_3O_8 production was discussed in detail in Reports No. 133 and 134.

5. It is assumed that annual demand will be greater than or equal to annual consumption. This

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has been borne out in uranium industry practice. To the extent that annual demand exceeds annual consumption, inventory is accumulated.

6. Inventory refers to natural uranium inventory (U_3O_8 and UF_6) held by utilities, reactor manufacturers and fuel fabricators; it does not include material held by US DOE. Difficulties in accounting precisely for the variety of possible forms, locations and ownership of uranium inventory necessarily result in some uncertainty in estimating the total US natural uranium inventory, but that uncertainty is minimized by the annual compilation and publication by US DOE of US inventory levels. Nuexco believes the US DOE estimate to be accurate to within ten percent. More important is the fact that the primary conclusions of this analysis are not sensitive to beginning inventory variations of up to 15 percent from the estimate of 66.4 million pounds U_3O_8 equivalent at the beginning of 1979.

7. Exports and imports refer to commitments in force as of this writing. Contracts under litigation are excluded.

8. Annual consumption is determined using the Nuexco estimate of Apparent Future Consumption, a concept introduced in Report No. 128 and updated in Report No. 132. It is important to note that Apparent Future Consumption takes no account of reactors not yet ordered. Consequently, Apparent Future Consumption will understate demand by the amount attributable to orders yet to be placed, as well as by inventory purchases.

9. The methodology used for Nuexco's estimate of Apparent Future Consumption is summarized below:

a. Estimates of Apparent Future Consumption should be regarded as a comparatively hard component of total demand, and relatively insentitive to uranium prices. Market demand for the assumed pattern of capacity additions can be higher, but is not likely to be lower.

b. Demand can exceed Apparent Future Consumption because of accelerated reactor construction schedules or inventory purchases by utilities.

c. Reactor loading is calculated for each reactor, based on its individual core characteristics. It is assumed that: 1) U_3O_8 deliveries for first cores predate commercial operation by two years; 2)first reload occurs 12 months after commercial operating date and annually thereafter; 3) U_3O_8 delivery for each reload predates reload by 18 months.

d. Actual commercial operating dates can differ widely from published dates. Nuexco uses the best information available, much of it from unpublished sources.

e. These estimates make no provision for orders not yet placed. Only the consumption associated with reactors operating, under construction or on order is included.

AUSTRALIA

This month's news was dominated by the announcement of the sales by the Ranger partners, Peko-Wallsend and Electrolytic-Zinc, to Korea Electric Company. The transaction involves 5,000,000 lbs. U_3O_8 for delivery over the ten-year period 1983-1992. Pricing is reported to be the higher of a negotiated market price and a partially escalated floor price. Significantly, this is the first new contract endorsed by the Australian government since 1972, and its importance to Australia and current Australian marketing efforts was underscored by the government's positive statement accompanying the sellers' press releases.

In addition to this transaction, at least three others involving Australian sellers and utility buyers have been agreed to in principle, although finalizing contract language and formal government approvals may take some time.

After a slow and uncertain start, Australian marketing efforts have accelerated. One unique feature has been the increasing degree of government involvement and interest. Mr. Anthony, Deputy Prime Minister and Minister of Trade and Resources, has been particularly prominent in the public promotion of Australian uranium. In addition, the Australian foreign service has been mobilized; several US utilities report visits by Australian trade commissioners whose aim is to assess interest and describe Australian goals and policies. This aggressive and coordinated effort reflects Australia's determination to gain a position in the world uranium market. The overall marketing strategy appears to emphasize large reserves, high grade, the opportunity to diversify sources of supply and Australia's record of reliability in supply of raw materials.

However, it should be noted that, based on available evidence, prices, terms and conditions are not

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being sacrificed in pursuit of this goal. Non-negotiable contract items are reported to include non-proliferation provisions, Australian delivery point, minimum and market-related prices and an insistence that buyers, with stated notice periods, accept up to 35 percent of scheduled deliveries after 1990 as natural or enriched UF_6 if conversion and enrichment capacity is available.

CANADA

Several transactions involving Canadian producers closed this month. One near-term transaction is reported at higher than Exchange Value, and two near-term sales to Pacific Basin buyers were concluded at prices related to market at the time of delivery. In addition, two large, well-publicized sales were announced this month involving the output of the Blizzard claims in British Columbia; the buyer in both cases was Korea Electric Company. The Blizzard partners involved in these sales (Norcen Energy Resources Ltd, Lacana Mining Corporation, E&B Explorations Ltd, and Geomex Resources Limited Partnership), expect production to begin in 1983. They estimate the property to contain reserves in excess of 10 million pounds U_3O_8. Development of the property is subject to approval of the provincial government.

UNITED STATES

Two transactions involving US sellers closed this month; one a small spot sale, the other a large intermediate-term transaction with a non-US buyer at a price related to market price at the time of delivery.

The US market for spot and near-term deliveries can currently be characterized as one in which the supply is very large relative to the demand. Totals of active inquiries to purchase or sell, listed in the *Market Opportunities* section of this Report (pp. 5.0 and 5.1), are as follows:

	Thousands of Pounds U_3O_8	
Year	Available for Sale	Inquiries to Purchase
1979	1,800	500
1980	1,650	1,250
Totals	3,450	1,750

While the supply is not overwhelming in an absolute sense, the following points are significant:

1. All 1.8 million pounds U_3O_8 available for sale in 1979 are "in the can" and ready for spot transfer.
2. Much of the material available for sale in 1979 is being offered by utilities seeking to reduce inventories.
3. It is presently seen as very likely that additional spot material will be actively offered within the next several months, perhaps in significant quantities.
4. Of the demand that does exist, a substantial portion is discretionary, primarily for additions to inventory.

All of the above factors would be expected to put downward pressure on prices, especially the presence of utility sellers in the market, since their reason for selling may be largely related to cash flow, and they thus might be willing to cut price in order to attract buyers.

Despite the generally bearish condition of the market, some observers point to at least three factors which may develop to somewhat mitigate the downward trend:

1. Some buyers are counting on receiving deliveries which might not be made, as a result either of disputes or technical problems. Litigation, which has developed in recent months in at least one case involving a large quantity of material, has prompted some concern. Also, some new facilities have experienced technical and regulatory problems.
2. A few producers may choose to cut back on production by closing or derating facilities which are now economically marginal. This will remove some material from competition in the near-term market.
3. If the market becomes extremely weak, and prices fall significantly, some utilities seeking to liquidate inventories may withdraw from the market if they find it difficult to justify selling at a loss.

PRICING

The **Exchange Value** decreased $1.20 this month to $41.00 per pound U_3O_8, resuming, after one month's respite, the decline that began in July of this year. Over the past six months, this decrease amounts to $2.25, or about 5 percent. If allowances for inflation are included, the real dollar decrease is about 10 percent.

The continuing price decline is attributable to a number of factors which have been present in the market for some time, and have been discussed in

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previous Reports. Demand has been decreased and stretched out in time as a consequence of the DOE's new enrichment contract. Demand has been further eroded by cancellations of planned nuclear facilities, stretch-outs of construction schedules, unexpected outages and delays in start-ups resulting from the Three Mile Island accident and other safety and licensing reasons, and planned outages associated with steam generator repairs and other upgrading.

While demand has ebbed, current and perceived future supply have continued to expand. Buyers view the forward supply situation as adequate and, as a consequence, there is little driving force to continue to build inventory as a hedge against future unavailability.

To these generally bearish conditions must be added two others. First, the market has lost much of the support provided by non-US buyers during 1978 and early 1979, as many of them complete their inventory building programs.

Second is the emergence of an increasing amount of US utility inventory in the spot market. While the potential has existed for some time, it is only now being realized. An important motive behind the decision of some utilities to sell from inventory might be the high cost of carrying uranium inventories at a time when interest rates are at record highs. Another related reason for inventory liquidation might be that it provides an alternate means of raising cash in a very tight credit market.

While conventional wisdom suggests that buyers are always pleased to see lower prices, there is reason to believe that at least some buyers have mixed emotions about the weakening price picture. The situation is of immediate concern to those utilities which seek to dispose of excess inventory. Also concerned are those utilities which may be taking deliveries under contracts with pricing mechanisms which produce prices in excess of the generally-perceived market price at the time of delivery.

A longer-term concern involves the reaction of the potential new producers to a weakening market. This is particularly true in the United States, with its high-cost, low-grade production. Many observers feel that recent market developments could lead to extended delays in the development of new production facilities.

The **Transaction Value** declined slightly this month to $43.50. While several transactions are reported, most have pricing provisions related to market price at the time of delivery. The calculation for the current Transaction Value has been extended over seven months in order to include a minimum of ten transactions and two million pounds. Thus, the weighted average is still dominated by transactions which closed several months ago, prior to the current period of decline in the Exchange Value. Inertia in the Transaction Value is expected, and is typical of any characteristic averaged over time.

LOAN USE CHARGE RATE

One uranium loan transaction closed this month, involving a large quantity of UF_6 for immediate delivery, with the repayment period extending through the mid-1980's. The interest rate in this transaction was slightly higher than the Nuexco Loan Use Charge Rate. However, the flexible payback provisions were seen by the borrower to compensate for the higher rate.

There are several additional inquiries in the market to borrow uranium at rates at or near the current Nuexco Loan Use Charge Rate of seven percent. Some Subscribers have inquired why the Loan Use Charge Rate for uranium has remained at seven percent, while the prime money market rate in the US is currently more than fifteen percent. The reason most often given by participants in the uranium loan market is that supply and demand for uranium loans are usually independent of supply and demand in the money market. Also, the money market is affected by inflation in a way that the uranium loan market is not. Interest rates in the money market are often thought to be the sum of the "real interest rate", risk and anticipated inflation. Anticipated inflation is included because in times of inflation, money returned will have a lower real value than money borrowed. Thus, the current high rates in the money market are seen to be caused by high anticipated inflation rates. In the case of a uranium loan, the uranium returned to the lender will have the same intrinsic fuel value as had the uranium borrowed.

Thus, the variable of anticipated inflation is removed, and the uranium loan use charge rate reduces to the sum of the real interest rate and risk. Under conditions of risk viewed as reasonable by most uranium lenders, uranium is currently availa-

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ble for loan in large quantities for several years, at rates less than half the current prime rate. Since concerns about the availability of replacement material have diminished, many observers expect activity in the loan market to increase.

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TOPICAL ESSAY

SPOT AND OTHER MARKETS

This is the third essay in a series on various facets of the uranium market.

Although there is no general agreement on their meaning, the terms *spot market, spot sale, spot purchase* and *spot price* are frequently used in the uranium industry. To attempt to define "spot" precisely is inviting debate, but, based on Nuexco's experience and discussions with a broad cross-section of the industry, it seems that spot transactions have certain common characteristics.

1. The uranium to be bought (or sold) is "in the can." That is, the material is in existence at contract signing and can be immediately identified with the contract. It might be in the form of U_3O_8 or UF_6, but, in either event, is ready for delivery, not still in the ground or in the form of unmilled ore. Physical location is not particularly important. The material could be at a mill or converter, at an enrichment facility or in transit.

2. Delivery and payment normally occur at, or shortly following, closing (contract signature).

3. Contracting is less complex than for transactions involving material yet to be produced. Simplified contracts are used, since there are fewer extenuating circumstances to address. In fact, closing is often expedited by using purchase orders, Telex exchanges or telecopied letter agreements in lieu of formal contracts.

4. Price is nearly always fixed, as delivery and payment take place at, or shortly after, closing.

Of these characteristics, the first, the existence of the uranium "in the can," appears to be the key in determining whether a transaction is a spot transaction. The subsequent characteristics stem from the first.

It can be argued that a contract with an established producer to purchase a specified quantity of U_3O_8 at a fixed price with delivery guaranteed on some specified future date, should also be viewed as a spot transaction. However, such an argument only raises the question of when a delivery ceases to be spot and becomes something else. Having uranium in the can appears to be a less arbitrary criterion than a cut-off date.

A spot price is the price paid in a spot transaction.

Near Term, Intermediate Term, and Long Term

These phrases are also used without an industry concensus regarding definition. To some, "term" refers to the length of time over which deliveries take place. To others, "term" refers to the period of time between contract execution and the conclusion of deliveries. The latter appears more useful, particularly where viewed in conjunction with such related items as specificity of delivery dates, quantities, elements of risk and pricing terms.

"Near term" through "long term" represents a time continuum and any breakdown may be viewed as arbitrary, but again, experience suggests the following:

1. *Near term.* Deliveries (excluding spot transactions) are concluded within 12 months of contract execution.

2. *Intermediate term.* Deliveries extend more than 12 months after date of contract execution but are concluded within five years of contract execution.

3. *Long term.* Deliveries extend more than five years beyond the date of contract execution.

As deliveries extend further into the future, other aspects of uranium contracts also change.

1. Contracts themselves typically become longer and more complex. There are more unknowns and "what ifs" to be addressed.

2. Delivery dates typically become less precise. Quantities to be delivered tend to become associated with months, calendar quarters or even years, rather than specific dates.

3. Quantities may also be less precise. Buyers or sellers may have the right to alter quantities within specified limits and/or after giving specified advance notice. If the seller is a new market entrant and/or deliveries are to be made from a new production facility, there may be reluctance to guarantee delivery of specific quantities due to licensing, production or technological uncertainties. In such cases, quantities may be expressed as a percentage of mine/mill output and may be subject to minimum and maximum limits. Arrangements under which the the producer is obligated to deliver only what he produces (or some percentage thereof), but which do not obligate production or deliveries of specific quantities, are known as output contracts.

4. Finally, there is price. As one moves from spot to near term to long term, pricing mechanisms tend to proliferate. Fixed prices give way to escalated base prices or cost plus arrangements. Market price features are likely to appear as the contract term

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TOPICAL ESSAY

lengthens. Provisions for renegotiation also become more frequent, as buyers and sellers predictably attempt to deal with an uncertain future.

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BY-PRODUCT URANIUM FROM PHOSPHATE — PART I

Introduction

Minable concentrations of phosphate occur in a variety of deposits, primarily in three different environments—igneous apatites, marine phosphorites and guano deposits. Uranium is present as a trace element in all phosphate occurrences. However, of these, marine phosphorites are of the greatest economic importance due to a higher phosphate content, larger quantities, and the relative ease in recovering uranium as a by-product. At this time, uranium recovery from apatites and guano is not economically feasible.

The world's phosphate resources are enormous. They are divided into two categories: identified reserves based upon known and tested mineral deposits; and hypothetical resources, based upon geologically predictable deposits.

Table 1 shows an estimate of phosphate resources in all geologic environments, plus estimated uranium content for each category.

Phosphate/Uranium Mineralization

Phosphate rock contains almost three percent fluorine and trace amounts of vanadium, as well as uranium. Uranium partially substitutes for calcium in apatite and crandallite, both calcium phosphate minerals. Thus, the uranium is considered to be syngenetic. Primary phosphate deposits contain low phosphate and uranium values. Higher-grade deposits are formed as a result of weathering and reworking of primary phosphate rocks and pebbles in a marine environment. The uranium content of a deposit increases in proportion to phosphate content. Secondary uranium minerals of tyuyamunite and torbernite have been identified in highly-weathered deposits; carnotite and autunite mineralization are common in fossil bones and teeth found in marine deposits.

Intensive alteration of phosphates by groundwater action and weathering produces aluminum phosphate minerals. Much of the apatite and part of the silicate are replaced to form wavellite, an aluminum phosphate, and crandallite, a calcium aluminum phosphate. The amount of phosphate varies from about six to ten percent in these deposits; uranium is enriched up to 0.012 percent U_3O_8 and is associated primarily with crandallite. The uranium content increases in proportion to calcium content. This type of mineralization is common to the Bone Valley area of Florida, where it overlies richer apatite deposits. Combined, these deposits represent a potentially valuable resource of phosphate, uranium and aluminum.

Types of Deposits

Primary igneous apatite deposits occur as intrusive masses, veins or pegmatites. Among these, the largest are the intrusive masses, usually associated with alkalic granite high in apatite. The apatite mineral is fluorapatite. Its content ranges from five to eight percent in veins and pegmatites. The size of a high-grade apatite deposit varies from a few hundred tonnes to hundreds of millions of tonnes. The uranium content of these deposits varies from 0.001 to 0.010 percent—below the current level for economical recovery.

The largest minable apatite deposits are located on the Kola Peninsula in the USSR. Other large deposits are located in South Africa, Uganda and

Table 1
WORLDWIDE PHOSPHATE RESOURCES & URANIUM CONTENT[1]

Type of Deposit	Identified Reserves[2]	Hypothetical Resources[2]	Percent Uranium
Marine	76×10^9	90×10^9	0.005 to 0.030
Igneous Apatite	3×10^9	10×10^9	0.001 to 0.010
Guano	184×10^6		0.001 to 0.003

[1] Adapted from "Uranium in Phosphate Rock," J.B. Cathcart, USGS Professional Paper 988-A, 1978.

[2] Tonnes of phosphate rock containing at least 20% P_2O_5.

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Brazil. About 21 percent of the world's phosphate production came from igneous apatite deposits in 1978, approximately 85 percent of which was produced from deposits on the Kola Peninsula.

Guano deposits are formed primarily from the excreta of sea birds. Phosphate-rich deposits are formed as the soluble phosphate in guano is dissolved by surface and ground water and carried downward to react with and alter the underlying rock. If the rock is limestone, apatite mineralization is formed; if it is of igneous origin, aluminum phosphates are formed. Deposits measuring many millions of tonnes have developed over extensive periods of time. About five percent of the world's phosphate production is from guano deposits.

Marine phosphorite deposits are known to exist in formations of all geologic ages from Precambrian to Pliocene (Tertiary). The thickest, richest deposits have formed in regional basins or synclines, associated with structural highs, locally referred to as platforms. Generally, these deposits show blanket deposition consisting of evenly-bedded and/or cross-bedded detrital phosphate sands and gravels, intermixed with phosphatic shales, sands and limestones. Phosphatized bone and shale fragments are common, and often contain greater amounts of phosphate and uranium. The P_2O_5 content of the deposits averages about 30 percent. In some cases, course-grained phosphate sediments occupy channels cut into the older rock, forming deposits containing an average of about 40 percent P_2O_5.

Most of the world's marine phosphorite deposits are located within the latitudes 40°N and 40°S. The deposits formed in warm, tropical ocean currents along an eastern coast of each continent. The phosphatic material was reworked by warm submarine currents and/or subjected to weathering, forming deposits which are potentially economically recoverable. The most important deposits of this type are located in the southeastern US and in the Mediterranean area along the northern limits of Africa.

Secondary deposits of uraniferous phosphorite are common, but much smaller than marine deposits. Extensive weathering of phosphate rock has created residual deposits. Apatite is more resistant to weathering than rock constituents such as carbonates; thus, calcite is weathered away from phosphatic limestone, resulting in higher-grade phosphate and uranium mineralization. The uranium content in these deposits will have an approximate range of 0.001 to 0.017 percent U_3O_8. The phosphate content may be comparatively high, although the deposits are usually small and only of local importance.

Certain Tertiary lake beds in Wyoming, Nevada and Utah contain thin, fine-grained, uraniferous phosphorite beds. The phosphate content varies from about 5 to 11 percent, the uranium content from 0.05 to 0.12 percent. Higher values of each mineral have been reported as isolated occurrences. Deposits in this environment are small and have only limited economic potential for uranium.

Phosphate and Uranium Resources

Marine phosphorite resources are considered to be either identified reserves—deposits evaluated for grade and tonnage, and considered to be economically recoverable using available technology—or hypothetical resources—undiscovered deposits in geologically favorable districts. World phosphorite resources are outlined in Table 2. Average uranium content and estimated uranium resources are also listed. The uranium content in identified reserves has been so uniform that the same values have been assigned to hypothetical resources. The estimate for total tonnes U_3O_8 includes all resources.

Production

World production of phosphate rock totaled 116 million tonnes in 1978, of which about 75 percent, or 87 million tonnes, was from marine deposits. By-product uranium is potentially recoverable from all marine phosphorites. However, no process has been developed to selectively extract uranium from phosphate rock. The method currently used in preparing for uranium recovery is acidulation, the complete digestion of the rock with sulfuric acid, and is commonly referred to as the "wet-process" for producing phosporic acid. Thus, the availability of uranium is currently limited to the application of wet-process technology. Of the total uranium present in the phosphate resources listed in Table 2, approximately one-half is recoverable using current technology.[1]

[1] Phosphoric acid is also made from elemental phosphorus. Uranium cannot be recovered from this. About eight percent of all phosphoric acid produced is from elemental phosphorus.

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Table 2
URANIUM RESOURCES IN MARINE PHOSPHORITES[1]

Resource Location	Phosphates		Estimated Uranium Content	
	Identified Reserves[2]	Hypothetical Resources[2]	Percent	Total Tonnes
United States	20×10^9	15×10^9	0.009	3,150,000
Africa	45×10^9	50×10^9	0.009	8,500,000
Mid-East & Asia	10×10^9	10×10^9	0.008	1,600,000
Latin America	5×10^9	5×10^9	0.008	800,000
Australia	5×10^9	10×10^9	0.006	780,000
Pacific Islands	0.2×10^9	0.1×10^9	0.005	15,000

[1] Adapted from "Uranium in Phosphate Rock," J.B. Cathcart, USGS Professional Paper 988-A, 1978.

[2] Tonnes of phosphate rock containing at least 20% P_2O_5.

Acidulation of phosphate rock is an intermediate step in the production of phosphoric acid. Uranium contained in the rock remains in the acid stream, from which 90 percent is potentially recoverable. Producers closely guard details of their respective recovery techniques, but solvent extraction is the basic process utilized to strip uranium from phosphoric acid. Actually, the recovery process is essentially the same as that developed on behalf of the US Atomic Energy Commission in the early and mid-1950's, with slight modifications developed through independent research and development studies by phosphate and/or uranium producers in the early 1970's.

Production capacity of wet-process phosphoric acid is presently about 27 million tonnes per year in the non-Communist world. US production was 9.75 million tonnes P_2O_5 in 1978. World wet-process acid production could potentially yield approximately 12,250 tonnes U_3O_8 annually. The US portion of production could yield about 4,400 tonnes of that total.[2]

The uranium recoverable through the acidulation process is dependent upon a number of conditions. First, recovery technology must be available—at least six US companies have recovery technology; three are recovering uranium, and three are preparing to do so within the next year; several foreign producers are interested, and plans have been announced for one production facility. Second, the economics of recovery must be favorable—demonstrated by the actions of the six US producers, all of whom have structured their recovery operations on a selling price of approximately US $40.00 per pound U_3O_8. Third, demand for uranium concentrate must be sufficient—evidenced by the fact that the above-mentioned companies pre-sold at least a portion of future production prior to initiating recovery plant construction.

Additional requirements relating to those already listed include: separating uranium recovery costs from phosphoric acid production costs—unofficially estimated to range from $28.00 to $35.00 per pound U_3O_8; phosphoric acid plant capacity—an annual capacity of 120,000 to 150,000 tonnes P_2O_5 is considered the minimum production level required to support an economical uranium operation; the uranium content of the incoming acid—a concentration of 120 to 150 mg/l is considered to be feasible for recovery; the acid to be processed should be free, or easily made free, of inorganic and organic contaminates to obviate additional processing; location of the uranium plant—the transfer of uranium-rich phosphoric acid to and from the uranium plant must be convenient for handling large volumes, possibly from more than one acid plant; and open-pit mining of large tonnages is required.

The phosphate deposits in the southeastern US are among the largest in the world, and are presently the most important to international markets. The deposits in Florida are, in turn, the most important in the US phosphate industry. Potentially minable phosphorite reserves for the district are approximately 12.0 billion tonnes, of which about 4.0 billion tonnes, economically minable by current methods,

[2] One tonne P_2O_5 contains one pound U_3O_8—an average for central and southern Florida only.

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are located in Florida. In 1978, approximately 5.3 million tonnes P_2O_5 were produced in Florida, of which about 4.3 million tonnes originated in the central and southern parts of the state. Based upon an estimated average uranium content of 0.015 percent for the 4.3 million tonnes, the phosphoric acid contained approximately 1,950 tonnes U_3O_8.

The central and southern deposits of Florida offer the greatest economic potential for the recovery of uranium from phosphoric acid operations relative to favorable mining conditions and higher uranium content (0.015% U_3O_8/tonne compared to an average of 0.008% for the rest of the district). These deposits have been estimated at 1.8 billion tonnes of minable phosphate, containing about 204,115 tonnes U_3O_8. As stated before, complete recovery of uranium is not currently feasible. Not all producers of phosphoric acid will opt to recover the uranium contained in their product.

Part II of this article will be included in Nuexco Report No. 137. It will contain a description of by-product uranium recovery operations and other phosphate activities throughout the rest of the world.

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STATISTICAL DATA

EXCHANGE VALUE — $41.00/lb U_3O_8

DEFINITION

The Exchange Value is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month.

DERIVATION

Nuexco bases the Exchange Value upon:

A. Data from recently completed transactions.
B. Data from pending transactions.
C. Firm bids to buy and firm offers to sell.
D. Prices purchasers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy, and prices sellers have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell.

COMMENTS

Nuexco does not consider the following in determining the Exchange Value:

A. The price of uranium delivered or to be delivered under old contracts.
B. The price of uranium delivered in connection with contract renegotiations or other than arm's length transactions.

TRANSACTION VALUE

Date	$/lb U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
This Month	43.50	2.7	17	7
Last Month	43.60	2.5	15	6
One Year Ago	43.40	2.1	13	4

DEFINITION

The Transaction Value is a weighted average price of recent transactions, and is based on prices paid for U_3O_8 in transactions closed within the previous three-month period and for which delivery was scheduled within one year of the transaction date. At least ten transactions totaling at least two million pounds U_3O_8 are included in each calculation, or the sample time is extended as necessary to include these minima. Foreign currencies are converted to US dollars as of the transaction date.

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STATISTICAL DATA

Figure 1
HISTORICAL EXCHANGE VALUES

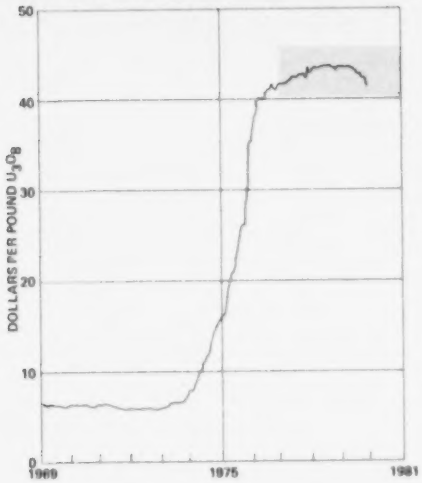


Figure 2
HISTORICAL TRANSACTION VALUES

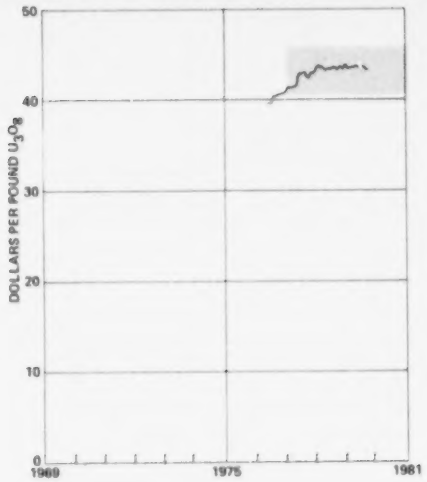
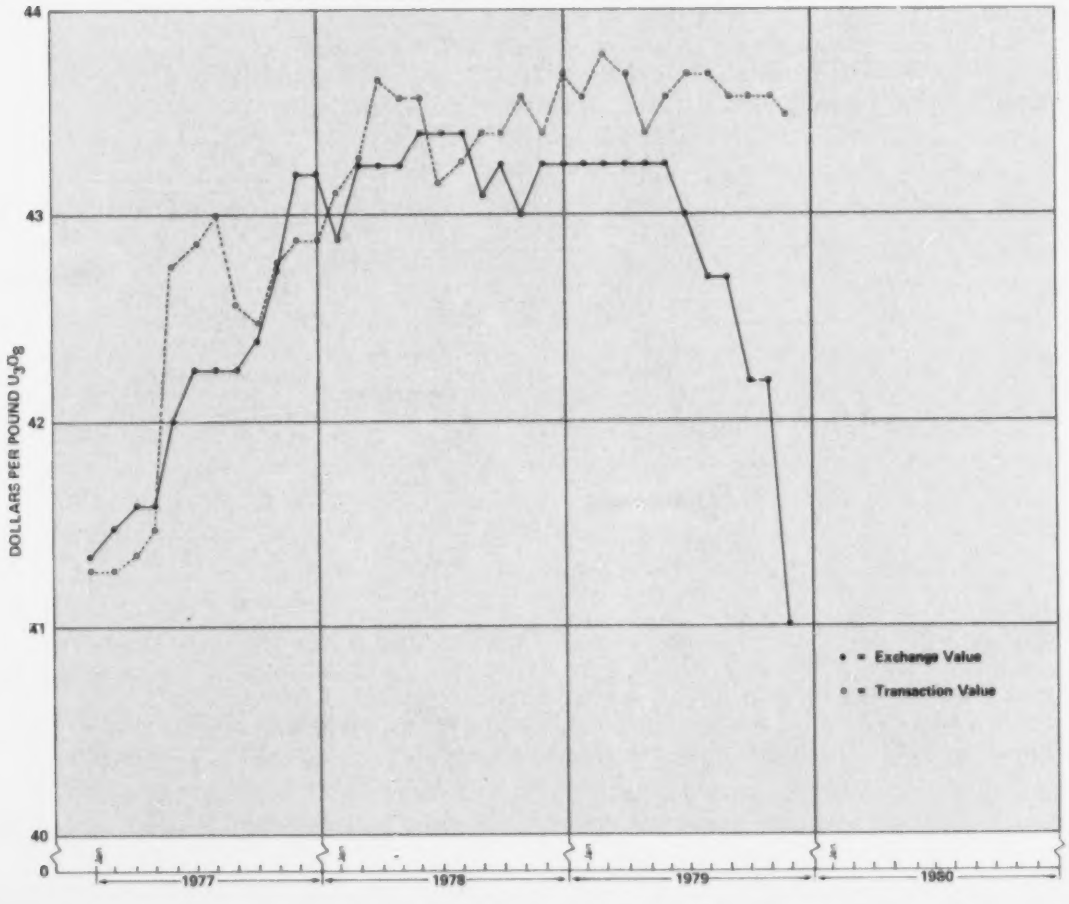


Figure 3
RECENT EXCHANGE AND TRANSACTION VALUES



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STATISTICAL DATA

EXCHANGE VALUE
US Dollars/lb U_3O_8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	–	–	–	–	–	–	–	6.35	6.35	6.40	6.45	6.50
1969	–	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	

Note: See earlier Nuexco Reports for evolution of the definition of Exchange Value.

TRANSACTION VALUE
US Dollars/lb U_3O_8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	–	–	–	–	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	

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STATISTICAL DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES*

Country	per lb U_3O_8 in Concentrates	per kg U_3O_8 in Concentrates	per kg U in Concentrates
US (dollar)	41.00	90.39	106.59
France (franc)	166.33	366.69	432.42
FRG (mark)	70.78	156.03	184.00
Japan (yen)	10,224	22,541	26,581
Switzerland (franc)	65.07	143.45	169.16
UK (pound)	18.67	41.15	48.53
Australia (dollar)	37.46	82.59	97.39
Canada (dollar)	47.98	105.78	124.74
Niger, Gabon (CFA)	8,316	18,335	21,621
South Africa (rand)	34.05	75.07	88.53

*Currency exchange rates as of the last business day of the month.

LOAN USE CHARGE RATE — 7.0%/year

DEFINITION

The Loan Use Charge Rate is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the last day of the month.

DERIVATION

Nuexco bases the Loan Use Charge Rate upon:

A. Data from recently completed or pending loan transactions.
B. Rates included in firm proposals to borrow or lend.
C. Rates that potential borrowers and lenders have expressed a willingness to pay or accept, but for which Nuexco is not aware of firm proposals.

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STATISTICAL DATA

CURRENT TRANSACTIONS*

Ref	Delivery Period	Material & Approximate Quantity	Approximate Price as % of Current E.V.	Seller Group	Buyer Group	Remarks
991	81-83	1,000,000 to 2,000,000 lbs U_3O_8	–	US	Pacific Basin	Price is market-related
993	79-81	300,000 to 600,000 lbs U_3O_8	–	Africa	Europe	Price is market-related
994	80	100,000 to 300,000 lbs U_3O_8	–	Canada	Pacific Basin	Price is market-related
998	79	Less than 50,000 lbs U_3O_8	100	US	US	
1000	83-92	4,000,000 to 7,000,000 lbs U_3O_8	–	Australia	Pacific Basin	Price is market-related
1001	83-93	2,000,000 to 4,000,000 lbs U_3O_8	–	Canada	Pacific Basin	Price is market-related
1006	79	1,000,000 to 2,000,000 lbs U_3O_8	–	US	US	Loan
1007	83-93	4,000,000 to 7,000,000 lbs U_3O_8	–	Canada	Pacific Basin	Price is market-related
1008	79-80	100,00 to 300,000 lbs U_3O_8	104	Canada	Canada	

* Transactions listed include not only those in which Nuexco was involved, but also all others of which Nuexco is aware.

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STATISTICAL DATA

US GOVERNMENT STATISTICS

	Producer Price Index—Industrial Commodities (1967 = 100)[1]	Gross Average Hourly Earnings of Production or Non-Supervisory Workers[2]		
		Metal Mining (SIC 10)	**Primary Non-ferrous Metals (SIC 333)[3]**	**Chemicals and Allied Products (SIC 28)**
Annual Avg. 1970[4]	110.0	3.88		3.69
Annual Avg. 1971[4]	114.0	4.12		3.94
Annual Avg. 1972[4]	117.9	4.49		4.21
Annual Avg. 1973[4]	125.9	4.82		4.48
Annual Avg. 1974[4]	153.8	5.43		4.85
Annual Avg. 1975[4]	171.5	6.13		5.37
Annual Avg. 1976[4]	182.3	6.75		5.89
Annual Avg. 1977	195.1	7.27	7.66	6.39
Annual Avg. 1978	209.4	8.26	8.56	7.01
July 1978	210.1	8.29	8.62	7.05
Aug 1978	211.4	8.43	8.66	7.06
Sept 1978	212.5	8.59	8.74	7.13
Oct 1978	214.7	8.64	8.83	7.19
Nov 1978	216.0	8.74	8.86	7.22
Dec 1978	217.2	8.76	8.97	7.28
Jan 1979	220.0	8.75	9.01	7.32
Feb 1979	222.5	8.85	9.02	7.32
Mar 1979	225.4	8.88	9.11	7.36
Apr 1979	229.0	9.07	9.49	7.50
May 1979	231.6	9.09	9.14	7.46
Jun 1979	234.0R	9.12	9.43	7.52
Jul 1979	237.2	9.32	9.57	7.60
Aug 1979	240.3	9.38	9.70	7.65
Sept 1979	243.8	9.61P	9.80P	7.71P
Oct 1979	248.5			7.77P

(1) Final revisions to 1977 data are as indicated. Producer Price Indexes are now routinely revised four months after they are first released to reflect the availability of late repcrts and corrections by respondents. Source: Bureau of Labor Statistics, *Producer Prices and Price Indexes*, Table 6. (Formerly *Wholesale Prices and Price Indexes)*

(2) Source: Bureau of Labor Statistics, *Employment and Earnings*, Table C-2.

(3) Monthly data for 1977 and 1978 appear in Report No. 125, dated December 31, 1978.

(4) Monthly data for these years appear in Section 10 of Report No. 107, dated June 30, 1977.

P = Preliminary

R = Revised

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MARKET OPPORTUNITIES

Market Opportunities are *active* inquiries in the uranium market to buy, sell, borrow or lend. The data presented in this section are in no way intended to be indicative of the entire uranium market for the time period covered.

SUPPLY

Uranium Available for Sale

Delivery Year	Pounds U_3O_8 (1000's)	Nuexco Reference Number	Remarks
1979	650	1325	
	350	1270	
	100	1292	
	500	1314	
	100	1274	
	100	1319	
1980	300	1274	
	350	1284	
	500	1324	
	500	1285	
1981	100	1306	
	300	1274	
	300	1286	
	500	1324	
1982	300	1274	
	200	1306	
	300	1286	
	200	1315	
1983	300	1286	
	200	1306	

Uranium Available for Loan

Delivery Year	Return Year	Pounds U_3O_8 (1000's)	Nuexco Reference Number	Remarks
1979	1982	725	1175	UF_6
	1983	1000	1196	
	1983	1000	1136	UF_6
	1983	1000	1239	UF_6
	1983	700	1234	

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MARKET OPPORTUNITIES

DEMAND

Inquiries to Purchase Uranium

Delivery Year	Pounds U_3O_8 (1000's)	Nuexco Reference Number	Remarks
1979	500	1323	
1980	350	1317	
	800	1268	
	100	1300	
1981	500	1228	
	200	1207	
	800	1260	
1982	300	1146	
	300	1227	
	200	1207	
	500	1228	
	400	1321	
1983	400	1321	
	250	1322	
	500	1228	

Inquiries to Borrow Uranium

Delivery Year	Return Year	Pounds U_3O_8 (1000's)	Nuexco Reference Number	Remarks
1979	1982	500	1121	
	1982-85	500	1135	
	1984	1000	1220	
	1983	1000	1240	

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EXECUTIVE SUMMARY & INDUSTRY OVERVIEW
NUEXCO REPORT NO. 136
Prepared Especially for Upper and Middle Management

This month's Report analyzes the supply/demand balance of natural uranium in the US. A continuation of current US buyer inventory policies could lead to a cumulative market for additional imports and new US production of about 100 million pounds U_3O_8 through 1990.

In Australia, the Ranger partners have announced a long-term sale of 5 million pounds U_3O_8 to Korea, for delivery from 1983-1992. This is the first new contract endorsed by the Australian government since 1972.

Six and a half million pounds of the output of the Blizzard claims in Canada have also been purchased by Korea. The property is estimated to contain more than 10 million pounds U_3O_8. Production is expected to begin in 1983.

In the current US spot market, supply far outweighs demand. Active inquiries for the balance of 1979 show a total of 1.8 million pounds U_3O_8 available, with inquiries to purchase only half a million pounds. Additional spot material, perhaps in significant quantity, is very likely to appear on the market in the next several months.

The continuing downward trend in the market is reflected by the **Exchange Value** , which dropped $1.20 in one month to $41.00 per pound U_3O_8. Demand remains low, as many buyers either see little driving force to build inventory or have already completed their inventory-building programs. The weakened market is of immediate concern to utilities seeking to unload excess inventory, and to those taking delivery under contracts with pricing mechanisms which have produced prices in excess of current market at time of delivery. **Transaction Value** declined slightly to $43.50.

This month's *Topical Essay* discusses spot and other markets.

Raw Materials offers the first of two articles on by-product uranium production from phosphate.

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